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TITLE: OUTPUT CORRECTING DEVICE OF TILT SENSOR FOR LEG TYPE MOVING ROBOT

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ABSTRACT:

PURPOSE: To improve drift correction accuracy of a tilt sensor by obtaining an interference angle obtained by assuming no action by compliance, and obtaining estimated floor reaction force from the interference angle so as to correct a sensor output in accordance with a difference from actual floor reac tion force, in an angle between a floor surface supposed by target walk capacity and the actual floor surface.

CONSTITUTION: An estimated tilt of a virtual plane including an tread estimated location is obtained by kinematic calculation from a robot attitude tilt estimated value and an articulated displacement detection value, and an estimated interference angle is obtained from a supposed floor surface tilt. Next from this estimated interference angle, estimated floor reaction force moment about a reference action point is obtained, based on a compliance model. Actual reaction force moment about the same action point to a 6-axis force sensor detection

value is obtained. Then from a difference between the estimated floor reaction force moment and actual floor reaction force moment, a correction value is calculated from a correction rule, to correct a tilt sensor output.

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]About the output compensator of the tilt sensor for leg formula mobile robots, in a known floor line, this invention presumes the relative posture of a robot over a floor line, presumes posture inclination of a robot, and more specifically relates to what amended the drift of the tilt sensor.
[0002]
[Description of the Prior Art]As a mobile robot, especially a leg formula mobile robot, the thing JP,62-97005,A and given in JP,63-150176,A etc. are known. About a robot including a leg formula mobile robot, it is detailed in a "robotics handbook" (edited by Robotics Society of Japan, October 20, 1990).
[0003]
[Problem(s) to be Solved by the Invention]By the way, the leg formula mobile robot is usually equipped with the tilt sensor, in order to perform attitude control. What presumes an angle of gradient, the thing which detects a gravity direction, or the thing which used them together is used for a tilt sensor by integrating with the output of an angle-of-inclination speed detection machine. However, there is inconvenience which the deviation of a point estimate emits with the drift of a detector in what integrates with an angle-of-inclination speed detection machine output, and in a gravity direction detection type thing. Although a deviation does not emit, a temperature drift occurs or the error of a detection value is changed in response to the influence of the inertia force by acceleration-and-deceleration movement of a robot. Although the used [together] type thing can compensate these faults mutually, a detection value cannot emit it and the influence of the inertia force by acceleration-and-deceleration movement of a robot can be reduced considerably, the influence of the temperature drift of a gravity direction detector does not improve at all compared with a gravity direction detection type simple

substance.

[0004]Therefore, the purpose of this invention cancels the above-mentioned fault, and presumes posture inclination of a robot by presuming the relative posture of a robot over a floor line in a known floor line, It is in providing the output compensator of the tilt sensor for leg formula mobile robots which amended the drift of the above-mentioned tilt sensor correctly.

[0005]

[Means for Solving the Problem]In order to solve the above-mentioned technical problem, as shown for example, in claim 1 paragraph, this invention, It is an output compensator of link-type a tilt sensor for leg formula mobile robots provided with an upper body and two or more legs, 1st means to set up a target gait for walking this assumption floor line top supposing a floor line which models said robot by a rigid body link, and plans a walk, 2nd means to detect posture inclination in case said robot actually walks, A posture of said robot is searched for from posture inclination detected at least, assuming that there is no action or modification by compliance given to said robot, 3rd means to search for relative physical relationship of a posture searched for and said assumption floor line, 4th means to presume floor reaction force and/or a moment which will be produced from relative physical relationship searched for if said leg grounds to said assumption floor line with compliance given to said robot according to the characteristic set up beforehand, It asked for a deviation of 5th means to ask for actual floor reaction force and/or a moment of said robot and presumed floor reaction force, a moment and actual floor reaction force, and/or a moment, and it constituted so that it might have 6th means to amend said posture detected inclination value based on a deviation for which it asked.

[0006]

[Function]

[0007]It notes being able to quantify the relative posture inclination of a robot to a real floor line from joint displacement and the real floor reactive force of a robot, Since the absolute posture of a robot when walking an existing Shiretoko side top using the concept is presumed and the detection value of the tilt sensor was amended, even if a drift arises in a tilt sensor, it can be amended well.

[0008]

[Example]Hereafter, the leg formula mobile robot of bipedal locomotion is taken for an example as a mobile robot, and the example of this invention is described. Drawing 1 is an explanation skeleton figure showing the robot 1 on the whole, and equips the leg link 2 of each right and left with six joints (the electric motor which drives it shows each joint for the facilities of an understanding). From a top to order, these 6 piece joints are the joints 10R and 10L (right-hand side is set to R and left-hand side is set to L.) for leg winding of the waist (circumference of the z-axis). Below The same joints 12R and 12L of the roll directions (circumference of a x axis) of the waist, The joints 14R and 14L of the pitch direction (circumference of the y-axis),

the joints 16R and 16L of the pitch direction of a knee region, Are the joints 18R and 18L of the pitch direction of an ankle part, and the joints 20R and 20L of the roll directions, and **** 22R and 22L are attached in the lower part, and an upper body (case 24) is provided in the top, and the control unit 26 is stored in the inside.

[0009]In the above, waist articulation comprises the joint 10R (L), 12R (L), and 14R (L), and an ankle joint comprises the joint 18R (L) and 20R (L). It is the thigh links 32R and 32L between waist articulation and a knee joint, and is connected by the leg links 34R and 34L between a knee joint and an ankle joint. Here, the leg link 2 can give six flexibility about a leg on either side, respectively, and it can give the movement toward a request to the whole leg, and it comprises driving these 6x2=12 piece joints (axis) at a respectively proper angle during a walk so that three-dimensional space can be walked arbitrarily. As stated previously, the above-mentioned joint consists of electric motors, and have reduction gears etc. which double the power the output further, but. Since it is stated to another application (Japanese Patent Application No. No. 324218 [one to], JP,3-184782,A) etc. and is not just going to make them in itself into the gist of this invention furthermore these people proposed those details previously, the explanation beyond this is omitted.

[0010]In the robot 1 shown in drawing 1, the publicly known 6 axial force sensors 36 are formed in an ankle part, The force component Fx of x and y which are transmitted to a robot via ****, and the direction of z, Fy, Fz, and the moment ingredient Mx of the circumference of the direction, My and Mz are measured, and the existence of landing of a foot, the size of the power in which it is added to a support saddle, and a direction are detected. The earthing switch 38 (it is a graphic display abbreviation at drawing 1) of a capacity type is formed in the four corners of **** 22R (L), and the existence of grounding of **** is detected. The tilt sensor 40 is installed in the upper body 24, and the angle of gradient and angle-of-inclination speed to the gravity (perpendicular) direction are detected as opposed to the z-axis within a x-z flat surface and a y-z flat surface on it. The rotary encoder which detects the rotation is provided in the electric motor of each joint. Although omitted in drawing 1, the origin switch 42 for amending the output of the tilt sensor 40 and the limit switch 44 for the measure against fail are formed in the proper position of the robot 1. These outputs are sent to the control unit 26 in the above mentioned upper body 24.

[0011]Drawing 2 is a block diagram showing the details of the control unit 26, and comprises a micro computer. In there, the output of the tilt sensor 40 etc. is changed into a digital value with A/D converter 50, and the output is sent to RAM54 via the bus 52. The output of the encoder which adjoins each electric motor and is arranged is inputted in RAM54 via the counter 56, and the output of the earthing switch 38 etc. is similarly stored in RAM54 through the waveform shaping circuit 58. In the control unit, the 1st and 2nd arithmetic unit 60 and 62 that consists of CPUs is formed, and amending the drift of the tilt sensor 40 so that it may state later, it

computes a target joint angle and the 1st arithmetic unit 60 sends it out to RAM54. The 2nd arithmetic unit 62 reads the desired value and the detected actual measurement from RAM54, computes a control value required for the drive of each joint, and outputs it to the electric motor which drives each joint via D/A converter 66 and a servo amplifier.

[0012]Then, operation of this control device is explained. Since the gist of this invention is in drift amendment of a tilt sensor, it sets and explains a focus to that point below.

[0013]Drawing 3 is a block diagram showing the operation, and drawing 4 is a flow chart which shows the operation.

[0014]Search for the floor reaction force to be produced if the floor line (it is henceforth called an "assumption floor line") which presumed the posture of the robot from a tilt sensor output and joint displacement, and was assumed with the target gait in this control when summarizing is contacted, and. A real floor reactive force is measured for it, and the tilt sensor output was amended according to the deviation. Namely, when floor reaction force is presumed using the detection value of a tilt sensor at least on the assumption that an assumption floor line is known and there is no shape deviation between real floor lines essentially, In not being in agreement with a real floor reactive force, it judges that the tilt sensor output itself [used as a presumed basis] was not right, and the sensor output was amended.

[0015]Apply a posture inclination presumption deviation (after-mentioned) to a posture detected inclination value (sensor output), and the posture inclination point estimate of a robot is more specifically calculated, A virtual flat surface including all the ground parts (usually **** 22R (L)) of the posture which assumes that there is no action or modification by compliance in a robot, and is searched for from it and joint displacement, or its part (henceforth) a "virtual plane" -- calling -- the angle (it is henceforth called an "interference angle".) for which it asks and which the virtual plane and assumption floor line make It is shown in drawing 5. It presumes. And by amending a posture inclination presumption deviation so that the floor reaction force presumed from the interference angle may be in agreement with a real floor reactive force, a more exact posture inclination point estimate is obtained and the sensor output was amended. This posture inclination presumption deviation is sensor output correction value. "Inclination" or an "inclination" is used in the sense of an angle of gradient on these specifications.

[0016]The interference angle between the posture (virtual plane) and assumption floor line (or real floor line) which assume that there is no action by compliance in a robot from the posture inclination of a robot and joint displacement which were described now, and are searched for from the intention, It has a model (it is henceforth called a "compliance model") showing the relation of the floor reaction force at the time of making it change so that the posture (virtual plane) may be grounded to an assumption floor line (or real floor line) by the action by compliance. The composition of the model is specifically simplified as follows.

[0017]1. Use an interference angle for the input of a model.
2. Although the floor reaction force which is an output of a model is generally expressed by the power and the moment which are committed at a certain pressure cone apex, Since posture inclination of a robot will hardly change even if the force component of floor reaction force changes if a standard pressure cone apex is set up the target ZMP of a target gait, or near the, even if the force component of floor reaction force is disregarded, it is not cared about. Then, the compliance model in this example is carried out as [make / only the moment ingredient of the floor reaction force of the circumference of a standard pressure cone apex / compute].
[0018]Hereafter, when it explains according to the drawing 4 flow chart, in S10, it is a posture inclination point estimate (after-mentioned.) of a robot. An initial value asks for the above mentioned virtual plane which includes the grounding presumptive region through a kinematics operation from a sensor output and a joint displacement detection value, Namely, it asks for the above mentioned virtual plane including the grounding presumptive region (pair of shoes common [22R / all] (L) or in part) in the world coordinate system whose perpendicular direction corresponds with one of the axes of coordinates in quest of the posture of the robot of survey based on the joint displacement detection value and posture inclination point estimate of a robot, It asks for a presumed interference angle by taking the difference of the virtual plane and assumption floor line which were searched for. Then, from the presumed interference angle for which S12 was followed and asked, it asks for the presumed floor-reaction-force moment of the circumference of a standard pressure cone apex (for example, target ZMP) based on said compliance model.
[0019]When this is explained with reference to drawing 6 thru/or drawing 8, drawing 6 is a side view of the robot which formed the mechanical compliance mechanism 100 in the ankle which these people proposed previously (Japanese Patent Application No. No. 137,881 [four to]). If there shall be no action by compliance, a virtual plane will be called for like a graphic display from a support-saddle ground part, and an interference angle will be called for like a graphic display between real floor lines. And when the compliance mechanism 100 operates, as shown in drawing 7, the compliance mechanism 100 bends only an interference angle (changing), and a floor-reaction-force moment occurs. This means that an interference angle can be presumed, if a floor-reaction-force moment is measured as shown in drawing 8. it grounds, when it assumes that this invention is materialized paying attention to such knowledge, and does not have an action by compliance -- I will come out -- the shape deviation of a virtual plane and floor line (an assumption floor line and a real floor line) including a part -- interference -- an angle -- it expressing notionally and, It was materialized from having thought that it could be quantitatively presumed from a floor-reaction-force moment. Therefore, the characteristic shown in drawing 8 through an experiment is prepared beforehand, and a floor-reaction-force moment is presumed from a presumed interference angle according to the

characteristic in S12.

[0020]"Compliance" the becoming word, The flexible action (The flexiblebehaviour of a robot or any associated.) to the external force of the tool which accompanies "robot or it so that it may define as ISO/TR 8373:1988 Mean tools in response to externalforces" and in the meaning to "compliance." What is depended on the mechanism which was mentioned above, and which these people proposed by Japanese Patent Application No. No. 137,881 [four to] previously, and was shown in drawing 6 (drawing 7), and the thing to depend on the control proposed by Japanese Patent Application No. No. 137,884 [four to] etc. are contained. However, in these specifications, it is used not only for it but for "compliance" in a meaning also including what is depended on modification (bending) of the links 32 and 34R of the illustrated robot (L), etc. Therefore, the "compliance" said on these specifications is used in a meaning larger than usual. In the 1st example, since it asks for the presumed inclination of a virtual plane using a joint displacement detection value, "compliance" here means what is depended on modification of the **** mechanism shown by drawing 6 (drawing 7) or a link.

[0021]Then, it progresses to S14 and the real floor reactive force moment of the circumference of the same pressure cone apex is calculated from the value detected with the 6 axial force sensor 36. Then, progress to S16 and by the amendment rule of a graphic display from the difference of a real floor reactive force moment and a presumed floor-reaction-force moment. It asks for the posture inclination presumption deviation which is a point estimate of the deviation of real posture inclination and a posture detected inclination value (output of the tilt sensor 40) (amending, when there is a previous value), and it adds to a posture detected inclination value continuously, and a posture inclination point estimate is calculated. Although a low pass filter type may be sufficient as an amendment rule, in order to make a regular estimated error small, it is desirable to include pure integration. In the case of the example, the transfer function of the amendment rule was made into K/S (however, K constant of integration).

[0022]Then, progressing to less than S18 and negating the influence of the posture inclination point estimate of a robot, and the difference of target posture inclination, the posture of a target gait is corrected so that target floor reaction force may occur.

[0023]That is, it progresses to S18 first and asks for the interference angle in an ideal state with a reverse compliance model from a target floor-reaction-force moment. This reverse compliance model is ******** shown in drawing 3, and is provided with the characteristic which becomes reverse [a previous compliance model and transfer function]. That is, in this example, since it is premised on giving the compliance characteristic proposed by earlier application to a robot, in order to generate the floor reaction force planned with a target gait, it is necessary to add beforehand a part for an action or the link modification by compliance. Then, the reverse compliance model like a graphic display is set up, and it asked for the interference angle in the ideal state.

[0024]Then, the point estimate of posture inclination and the difference of target posture inclination are subtracted on the interference square in the ideal state which he followed to S20 and was searched for, and interference angle instructions are determined as it. Since a moment produces only the part to which the upper body leans, this is for canceling it. Then, the correction posture in which progressed to S22 and the interference angle to the assumption floor line of a target gait was corrected to interference angle instructions is searched for, it progresses to S24, and joint displacement of a real robot is made to follow by making joint displacement of a correction posture into a joint displacement command.

[0025]The posture inclination point estimate calculated by S16 is used by S10 at the time of the next loop of the drawing 4 flow chart, and a presumed interference angle is called for, It is corrected in the form where a posture inclination presumption deviation amends a previous value by S16 from the calculated value, and a posture inclination point estimate is again corrected using the corrected posture inclination presumption deviation. Thus, when one side repeats correction while on the assumption that another side, a posture inclination point estimate is converged on true posture inclination. By the loop of the beginning of the drawing 4 flow chart, the posture inclination presumption deviation is set to the proper initial value, for example, zero.

[0026]Although the posture was corrected in S18 thru/or S22, amendment of a posture detected inclination value is for being directly unrelated and coinciding a real floor reactive force with target floor reaction force, and this does not have a relation with a direct gist of this invention.

[0027]Since this example was constituted like the above, even if a drift arises in the tilt sensor 40 in a known floor line, it can be amended well. Since the wide range average inclination is almost level even if there is a response with a fine floor line of buildings, such as a building, it is suitable for such a place especially.

[0028]Drawing 9 is a block diagram showing the 2nd example of this invention, and drawing 10 is a flow chart which shows that operation. Like a graphic display, the point (S100 of the drawing 10 flow chart) which considered the presumed interference angle inputted into a model as interference angle instructions is different from the 1st example in the 2nd example. In the 2nd example, since not a joint angle displacement detection value but interference angle instructions are used for asking for a presumed interference angle, the "compliance" in the 2nd example contains both what is depended on modification of a mechanism or a link, and the thing to depend on control. Residual composition and effect do not differ from the 1st example.

[0029]Drawing 11 is a block diagram showing the 3rd example of this invention, and drawing 12 is a flow chart which shows that operation. In the 3rd example, it is different from the 1st example like a graphic display with the point (S200 of the drawing 12 flow chart) of having

taken the difference with an assumption floor line in quest of the presumed inclination of a virtual plane from the posture inclination point estimate of a robot, a joint displacement detection value, and the weighted mean (value) of the joint displacement command (value), and presuming the interference angle. If the coefficient of dignity sets it of the joint displacement detection value of a certain joint to W (S), it of a joint displacement command (value) will become (1-W(S)), but. At this time, take the contribution to compliance operation into consideration, and the large joint of a contribution enlarges dignity of a joint displacement detection value, and. If a small joint is made small, it will also become possible to be able to use a joint displacement command value almost as it is, and to reduce the operation amount in a kinematics operation of the small joint of a contribution. The frequency of the action of joint displacement may be taken into consideration besides it. Since the high frequency noise is contained in the joint displacement detection value, it is much more good to give the low pass filter characteristic to W (S). Since the 3rd example is mixing the composition of the 1st example and the 2nd example like a graphic display, "compliance" here contains what is depended on modification of a part of thing to depend on control, a mechanism, or a link. Residual composition and effect do not differ from the 1st example.

[0030]Drawing 13 is a block diagram showing the 4th example of this invention, and drawing 14 is a flow chart which shows that operation. There is the feature of the 4th example in having obtained the posture inclination presumption deviation from the floor-reaction-force moment in quest of the interference angle contrary to an old example like a graphic display. That is, the reverse compliance model previously shown in drawing 3 etc. is connected to the next step of 6 axial force sensor and its processing arithmetic machine, and the interference angle (referred to as the 1st) was presumed in quest of the posture of a robot from the detected floor-reaction-force moment. On the other hand, it asks for a presumed interference angle (referred to as the 2nd) as usual from the difference of the presumed inclination of a virtual plane and assumption floor line inclination including the grounding presumptive region, and asked for the posture inclination presumption deviation according to the deviation of those presumed interference angles. In more detail, in order for the same dimension to compare the 2nd presumed interference angle with the 1st presumed interference angle, if it says with the composition of drawing 3, a reverse compliance model will be connected to the next step of a compliance model, but. Since the product of the transfer function of both models is then set to 1, both will be offset as a result.

[0031]According to the difference in the above-mentioned composition, from S302 to S306 is different in the drawing 14 flow chart as compared with the drawing 3 flow chart of the 1st example. Residual composition is not different from the 1st example. Although the example which replaces with a floor-reaction-force moment and amends a sensor output using an interference angle is shown only when the 1st example is transformed, but it is not restricted to

this and an indication is omitted, a possible thing cannot be overemphasized by transforming the 2nd example or the 3rd example.

[0032]In the composition of the 1st to 4th above mentioned example, when asking for a joint displacement command from interference angle instructions and a target gait at a one leg support term, only the joint displacement command of a support-saddle ankle may be corrected. Since a reverse kinematics operation becomes unnecessary then, an operation amount decreases substantially.

[0033]In said composition, it is performing comparison with a point estimate and a detection value about a floor-reaction-force moment, and floor shape is presumed. Generally, floor reaction force is expressed with the power of being with power, a moment, and a pressure cone apex, or acting on ZMP and ZMP, and the moment of a floor normal line direction. What is necessary is to search for only a required element, since all ingredients are not concerned with attitude control even if it is expression [which]. Only what also has a required model may be outputted. If floor reaction force is expressed by making the target ZMP of a target gait into a standard pressure cone apex, since a force component hardly involves to the action of posture inclination, it may be omitted. The output of a model may be the amount of gaps of the ZMP position of the floor reaction force of a model, and the target ZMP. A standard pressure cone apex may be set on a part and an ankle (intersection of the ankle joints 18 and 20R (L)) with a robot. That is, if an ankle moment is used instead of the floor-reaction-force moment in an example, control of an ankle moment will be realized.

[0034]In said composition, although "inclination" and an "inclination" shall mean an angle of gradient, the value which replaced with the angle of gradient and carried out linear combination of angle-of-inclination speed or both may be used.

[0035]In a one leg support term, the limit that a floor-reaction-force moment could be generated was decided by the size and vertical floor reaction force of **** sidewall, and it has the nonlinear characteristic as shown in the compliance model below drawing 3. Naturally the reverse compliance characteristic is also nonlinear, and if target floor reaction force becomes large, the interference angle which is an output will become large rapidly. It is better to provide the limiting circuit of an interference angle in a reverse compliance model so that an interference angle may not become large even if target floor reaction force becomes large too much since it is not preferred that the interference angle of a real robot becomes not much large. Or it is also good to prevent linearizing the characteristic of a reverse compliance model and an interference angle becoming large rapidly.

[0036]Since the compliance characteristic changes with the cycles of a walk, such as a one leg support term and a double stance phase, if the compliance model in the above mentioned composition is also changed by the stage of a walk, the estimation precision of a posture inclination point estimate will become high.

[0037]Although the compliance model shown in the above mentioned composition has given only spring characteristics and damping characteristic is not taken into consideration, to the robot provided with damper characteristics, the model in consideration of damping characteristic may be set up.

[0038]After being completed by the presumed deviation by an amendment rule in presumption of a posture inclination presumption deviation, even if it changes floor reaction force, should not change the presumed deviation, but. When a compliance model differs from the compliance of a real robot, if floor reaction force is changed, amendment of a presumed deviation will malfunction and a presumed deviation will also be changed. If it tries to perform posture stabilization control using a posture inclination point estimate, delay occurs by this malfunction, and since the amendment rule comprises integration and a low pass filter element, oscillating will also be considered when the worst. What is necessary is just to perform the adaptive control which sets a compliance model by an identified value, identifying the compliance of a real robot, in order to prevent it. In adaptive control, change of the presumed floor reaction force usually outputted from a compliance model when a real floor reactive force is changed is observed, and the amount of change is identified so that it may be in agreement with the amount of change of a real robot.

[0039]Although it has explained taking the case of the leg formula mobile robot of bipedal locomotion in the above, it is not restricted to it, and appropriate [of this invention] is carried out also to the leg formula mobile robot of 3 or more pairs of shoes, and also it carries out appropriate to the mobile robot of other gestalten, such as not only a leg formula but a wheel type, and a crawler type.

[0040]

[Effect of the Invention]If it is in claim 1 paragraph, it is an output compensator of link-type the tilt sensor for leg formula mobile robots provided with an upper body and two or more legs, 1st means to set up the target gait for walking this assumption floor line top supposing the floor line which models said robot by a rigid body link, and plans a walk, 2nd means to detect posture inclination in case said robot actually walks, The posture of said robot is searched for from the posture inclination detected at least, assuming that there is no action or modification by the compliance given to said robot, 3rd means to search for the relative physical relationship of the posture searched for and said assumption floor line, 4th means to presume the floor reaction force and/or the moment which will be produced from the relative physical relationship searched for if said leg grounds to said assumption floor line with the compliance given to said robot according to the characteristic set up beforehand, 5th means to ask for the actual floor reaction force and/or moment of said robot, And ask for the deviation of the presumed floor reaction force, a moment and actual floor reaction force, and/or a moment, and since it constituted so that it might have 6th means to amend said posture inclination based on

the deviation for which it asked, even if a drift arises in a tilt sensor, It can be amended with sufficient accuracy.

[0041]If it is in claim 2 paragraph, it is an output compensator of link-type the tilt sensor for leg formula mobile robots provided with an upper body and two or more legs, 1st means to set up the target gait for walking this assumption floor line top supposing the floor line which models said robot by a rigid body link, and plans a walk, 2nd means to detect posture inclination in case said robot actually walks, 3rd means to search for the posture of said robot from the posture inclination detected at least, and to search for the 1st relative physical relationship of the posture searched for and said assumption floor line, 4th means to ask for the actual floor reaction force and/or moment of said robot, 5th means to search for the 2nd relative physical relationship of the posture of said robot, and said assumption floor line according to the characteristic set up beforehand from the actual floor reaction force searched for and/or a moment, And since it constituted so that it might have 6th means to ask for the deviation of the said 1st and 2nd relative physical relationship, and to amend said posture detected inclination value based on the deviation for which it asked, even if a drift arises in a tilt sensor, it can be amended with sufficient accuracy.

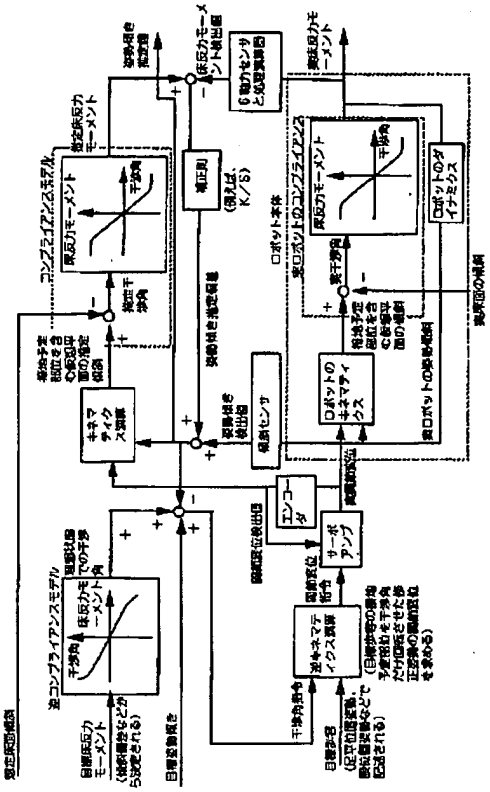
[0042]If it is in claim 3 paragraph, since it constituted so that said posture might be calculated from said detected posture inclination and the joint displacement detection value of the link of said robot, said 3rd means can amend it well, even if a drift arises in a tilt sensor.

[0043]If it is in claim 4 paragraph, said 3rd means can amend it well, even if a drift arises in a tilt sensor, though it is simple composition, since it constituted so that said posture might be calculated from said detected posture inclination and the joint displacement command value of the link of said robot.

[0044]Since said 3rd means was constituted so that said posture might be calculated from the arithmetic weighted mean of said detected posture inclination, and the joint displacement detection value of the link of said robot and a joint displacement command value if it was in claim 5 paragraph, For example, the above mentioned effect can be mentioned, enabling the contribution to compliance operation to use the command value of a low joint as it is etc., and reducing an operation amount.

[Translation done.]

Drawing selection Representative drawing



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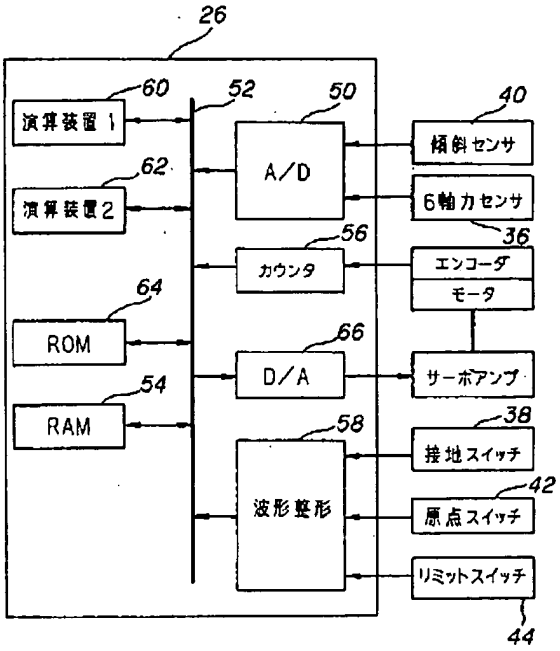
Drawing selection Drawing 2



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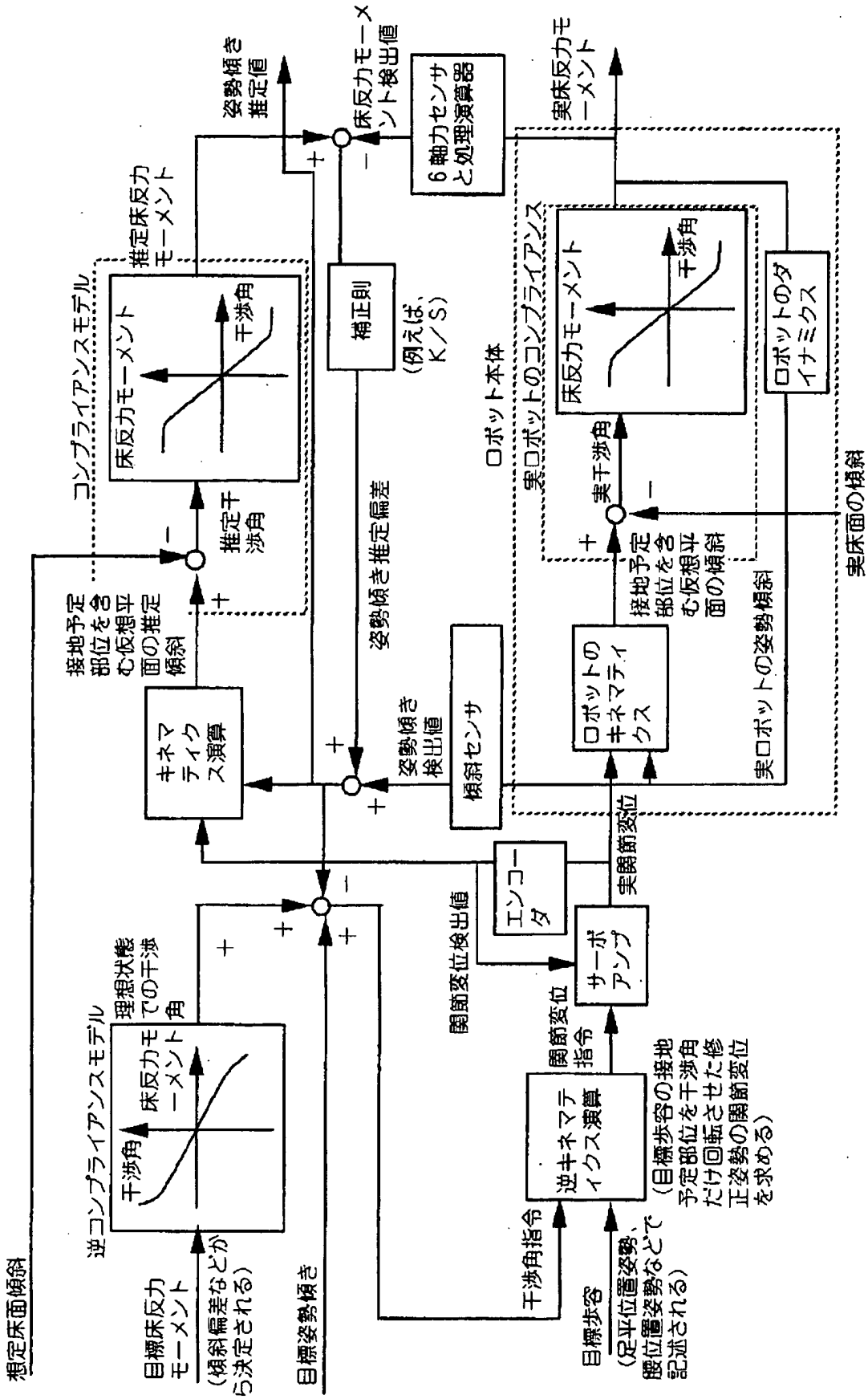
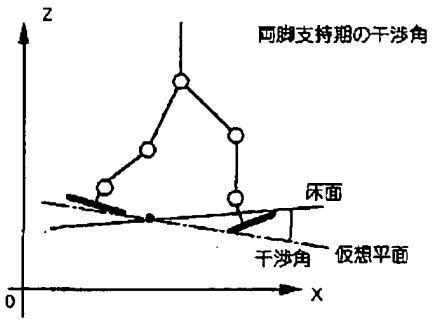
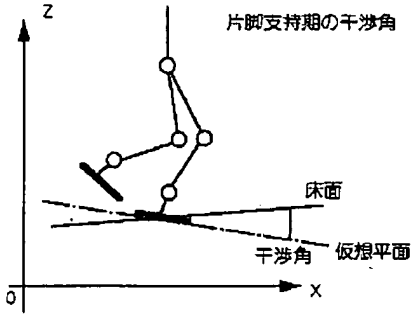

想定床面傾斜
目標床反力モーメント
(傾斜偏差などから決定される)
逆コンプライアンスモデル
干渉角
床反力モーメント
理想状態での干渉角
目標姿勢傾き
干渉角指令
逆キネマティクス演算
目標歩容
(足平位置姿勢、腰位置姿勢などで記述される)
(目標歩容の接地予定部位を干渉角だけ回転させた修正姿勢の関節変位を求める)
関節変位指令
サーボアンプ
関節変位検出値
エンコーダ
実関節変位
傾斜センサ
姿勢傾き検出値
キネマティクス演算
接地予定部位を含む仮想平面の推定傾斜
姿勢傾き推定偏差
補正則
(例えば、K／S)
コンプライアンスモデル
床反力モーメント
干渉角
推定干渉角
推定床反力モーメント
姿勢傾き推定値
床反力モーメント検出値
6軸力センサと処理演算器
実床反力モーメント
ロボット本体
実ロボットのコンプライアンス
床反力モーメント
干渉角
実干渉角
ロボットのダイナミクス
ロボットのキネマティクス
接地予定部位を含む仮想平面の傾斜
実ロボットの姿勢傾斜
実床面の傾斜

Drawing selection Drawing 5





[Translation done.]